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UREDINEOUS INFECTION EXPERIMENTS IN 1902.(¹)

W. A. KELLERMAN.

(²) A series of sixty-seven experiments were carried on in 1902, beginning April 7 and ending June 24. All were performed with host-plants previously transferred to the greenhouse, and were at the time of attempted inoculation, with few exceptions, in a satisfactory growing condition. Plants not removed from their natural habitat were used later in the season in a very few cases, but the method of procedure in the experiments was the same as that followed in the greenhouse.

Seventeen forms of Uredines were used in the inoculations. Of these seven yielded satisfactory results. In a case of two so meagre evidence was obtained that it is best to regard them, if artificial inoculations at all, at least as undecisive.

Infections were made in the usual way, namely by moistening the supposed host-plant by means of an atomizer; then depositing on the tender growing portions a quantity of the spores supposed to be viable. The plants were immediately covered with a bell-jar or suitable substitute therefor — this removed daily or oftener, but only long enough to repeat the use of the atomizer. After ample time for germination of the spores the covers were discarded.

Precautions were taken to guard against possible accidental infection. Spores of only one Rust species were used on any one day, and so far as practicable scalpels, forceps, camel's-hair brushes, and watch crystals were used but once; or if again needed were called into requisition only after thorough cleansing and disinfection.

At any one part of the work table or bench in the greenhouse, inoculations were never made with more than one species of Rust. It was feasible to carry on the work in different places, as in different sections of the greenhouse, different laboratory rooms, etc. This was believed to be a safeguard — possibly over cautious — against accidental infection.

In the earlier experiments a cover for the host-plant, a cylinder 18 to 20 inches high made of coarse wire netting and surrounded with muslin, was very satisfactory. Later, when the greenhouse was more freely ventilated, the evaporation was too rapid, and bell-jars or suitable frames made of narrow strips of galvanized iron with glass sides and tops were substituted. The plants were usually kept covered 3 or 4 days — or even 5 or 6

(¹) Contributions from the Botanical Laboratory of the Ohio State University. XI.

(²) The substance of this paper was presented before the Botanical Society of America, Jan. 1, 1903, under the title Uredinous Infection: Suggestions and Experiments.

days, a longer period than most experimenters consider necessary.

It is thought by some who have carried on uredinous inoculations extensively, that infection work in advance of the normal season of the parasitic species is fruitless effort. This is perhaps true in many cases, but my experiments with Puccinia atkinsoniana shows that it may be profitable. With this species inoculations were made on Sambucus canadensis April 7, the host-plant having been transplanted to the greenhouse January 10. The old leaves of Carex lurida harboring the teleutospores, exposed in their natural habitat all winter, were placed in the warm greenhouse a month and a half in advance of their use. Evidences of successful inoculation were noticeable April 15. By this early success it was possible to verify the result by repetitions of the experiment, as was done April 19 with corroborative result, also again April 25 with similar outcome, and for the fourth time — on host-plants growing out of doors — May 15, with a quadruply conclusive result. Using the teleutospores of Puccinia bolleyana on Sambucus canadensis in the greenhouse April 24, spermogonia and æcidia were obtained. This experiment was repeated May 24 on plants growing out of doors and in due time the former result was corroborated.

By this pre-season inoculation when possible, the correctness of first results can be verified the same year. This is advantageous — especially in the remarkable case cited above where apparently similar æcidia have been obtained on Sambucus by sowing spores of — as heretofore understood — two morphologically different species.

The experiments enumerated below include failures as well as successes. The latter can be repeated for verification and the former may to some extent, perhaps, be a guide to other experimenters. When work on the American species has been more extensively performed, the literature can doubtless be saved the burden of so numerous failure-records. It may yet be profitable, perhaps, to undertake more or less work with barely perceptible or vaguely suspected clues, though the advantage of experiment with previously observed evidence or very strong hints of relationship is fully appreciated.

PUCCINIA ATKINSONIANA DIET. (3) FROM CAREX LURIDA.

Exp. 1. April 7. Teleutospores sown on Sambucus canadensis. — Spermogonia appeared April 15; aecidia April 24.
Exp. 2. April 19. Teleutospores sown on Sambucus canadensis. — Spermogonia April 25; aecidia April 30.
Exp. 3. April 19. Teleutospores sown on Sambucus canadensis. — Spermogonia April 25; aecidia April 30.

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(3) Puccinia sambuci (Schw.) Arthur n. n., Bot. Gaz. 35:15. Jan. 1903.

Exp. 5.	April 25.	Teleutospores sown on Sambucus canadensis. — Aecidia May 7.
Exp. 6.	April 25.	Teleutospores sown on Onagra biennis. — No infection.
Exp. 7.	April 27.	Teleutospores sown on Impatiens biflora. — No infection.
Exp. 8.	April 27.	Teleutospores sown on Urtica gracilis. — No infection.
Exp. 32.	May 7.	Teleutospores sown on Sambucus canadensis. — Spermogonia May 14; aecidia May 24.
Exp. 33.	May 7.	Teleutospores sown on Onagra biennis. — No infection.
Exp. 44.	May 14.	Teleutospores sown on Sambucus canadensis. — Spermagonia May 23; aecidia May 26.
Exp. 45.	May 14.	Teleutospores sown on Sambucus canadensis. — Spermogonia May 23; aecidia May 26.

It will be seen from the above that, using the teleutospores of Puccinia atkinsoniana, successful inoculation followed only when the Elder (Sambucus canadensis) was used as the host — Onagra biennis, Impatiens biflora, and Urtica gracilis not being susceptible. The Rust was identified by Dr. J. C. Arthur, who informed me that it had been compared with the type. In spite of the fact that I had early in the winter entertained the opinion, based on field observation, that the alternate form of this Rust was the Aecidium on Elder, the result of the first inoculation (Exp. 1) was a matter of much astonishment, because in the meantime it had been learned that æcidia on Elder had been obtained, by Dr. Arthur, by sowings of teleutospores of Puccinia bolleyana Sacc. from Carex trichocarpa (cfr. Jour. Mycol. 8:55, June 1902). Believing that a mistake might perhaps in some way have occurred, additional experiments were instituted in the greenhouse, namely, Expts. 2 and 3 above. The result was a duplication of the first. The same can be said of Exp. 5, still later carried on. I could scarcely maintain a skeptical attitude in the case longer, yet it was determined to perform the work once again. This time it was decided to select host-plants growing out of doors in a neighboring grove. The decisive results again obtained, see Expts. 44 and 45, could allow no possible doubt — especially since the numerous unprotected plants, adjacent as well as at a distance, were entirely free from æcidia. Finally it may be said that the æcidia obtained by the inoculations were apparently the form ordinarily designated as Aecidium sambuci Schw.

PUCCINIA BOLLEYANA SACC.(4) FROM CAREX TRICHOCARPA.

Exp. 4.	April 24.	Teleutospores sown on Sambucus canadensis. — Few spermogonia May 1; few aecidia May 14.
Exp. 46.	May 14.	Teleutospores sown on Sambucus canadensis. — Few spermogonia May 23; few aecidia May 26.

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(4) Puccinia sambuci (Schw.) Arthur n.n. Bot. Gaz. 35:15. Jan. 1903.

Exp. 47. May 14. Teleutospores sown on Sambucus canadensis. — Few spermogonia May 23; few aecidia May 26.

It will be observed that teleutospores of Puccinia bolleyana Sacc. from Carex trichocarpa, kindly furnished me for culture by Dr. Arthur from the type locality in Indiana, as well as of Puccinia atkinsoniana Diet. from Carex lurida infect the Elder (Sambucus canadensis); no differences were observed in the resulting æcidia. But this is a subject for further study.(5) As stated above, Dr. Arthur has previously reported successful infection using the same species of parasite and host. Cfr. Jour. Mycol. 8:55, June 1902.

PUCCINIA PECKII (DETONI) KELLERM. (P. CARICIS AUCT.) FROM CAREX TRICHOCARPA.

Exp. 14. April 29. Teleutospores sown on Sambucus canadensis. — No infection.
Exp. 15. April 29. Teleutospores sown on Urtica gracilis. — No infection.
Exp. 16. April 29. Teleutospores sown on Impatiens fulva. — No infection.
Exp. 26. May 4. Teleutospores sown on Onagra biennis. — Spermogonia and immature aecidia. (Host failed in health and died.)
Exp. 27. May 4. Teleutospores sown on Impatiens biflora. — No infection.

Sowings on one host only, namely, the Common Evening Primrose (Onagra biennis) were successful; the æcidia known as Ae. peckii DeToni (*Ae. oenotherae* Peck) therefore is the alternate form of the rust on Carex trichocarpa previously designated as Puccinia caricis, and the name to be used is Puccinia peckii (DeToni) Kellerm. This was published May 31, 1902 (Jour. Mycol. 8:20, May 1902.)

PUCCINIA CARICIS (SCHUM.) REB. FROM CAREX RIPARIA.

Exp. 18. April 30. Teleutospores sown on impatiens biflora. — No infection.
Exp. 19. April 30. Teleutospores sown on Pentstemon pubescens. — No infection.
Exp. 20. April 30. Teleutospores sown on Rumex crispus. — No infection.
Exp. 21. April 30. Teleutospores sown on Sambucus canadensis. — No infection.
Exp. 22. April 30. Teleutospores sown on Onagra biennis. — No infection.
Exp. 23. April 30. Teleutospores sown on Urtica gracilis. — Abundant aecidia May 8.

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(5) Cfr. Bot. Gazette, 35:15. Jan. 1903. The paper of Dr. Arthur here referred to was received while my article was going through the press. He says, "These discoveries led to a careful microscopic study of the two Carex rusts, and there appears to be no reason to question that *P. atkinsoniana* and *P. bolleyana* are identical. In the designation of the species it seems necessary on grounds of priority to abandon both these names, however, and it becomes *Puccinia sambuci* (Schw.) Arthur n. n."

Experiment 23 demonstrated the correctness of the identification of the Rust (Puccinia caricis [Schum.] Reb.) on Carex riparia, whose alternate form is Aecidium urticæ Schum.

PUCCINIA CARICIS (SCHUM.) REB. FROM CAREX STRICTA.

Exp. 24. May 2. Teleutospores sown on Urtica gracilis.
— Abundant aecidia May 15.
Exp. 25. May 2. Teleutospores sown on Impatiens biflora.
— No infection.

The above experimentally verifies the identification of the common Rust on Carex stricta, its æcidial form being Aecidium urticæ Schum.

PUCCINIA ANDROPOGONIS SCHW. FROM ANDROPOGON SCOPARIUS.

Exp. 11. April 26. Teleutospores sown on Pentstemon hirsutus.
— Spermogonia May 10. (Host killed by Damping-off.)

The material for making the inoculation was kindly furnished by Dr. J. C. Arthur, Lafayette, Indiana. The result is a corroboration of work previously done by him.

PUCCINIA WINDSORIÆ SCHW. FROM TRICUSPIS SESLERIOIDES.

Exp. 36. May 11. Teleutospores sown on Impatiens biflora
— No infection.
Exp. 39. May 11. Teleutospores sown on Lycopus sinuatus.
— No infection.
Exp. 40. May 11. Teleutospores sown on Pentstemon pubescens.
— No infection.
Exp. 41. May 11. Teleutospores sown on Ptelea trifoliata.
— Abundant spermogonia May 19; aecidia May 25.
Exp. 42. May 11. Teleutospores sown on Ptelea trifoliata.
— Spermogonia May 18; aecidia May 25.
Exp. 43. May 11. Teleutospores sown on Ptelea trifoliata.
— Spermogonia May 18; aecidia May 25.

Thanks are extended to Dr. J. C. Arthur for the culture material and for the host plants used in Experiments 42 and 43. The results obtained when the teleutospores were sown on Ptelea trifoliata corroborate the work by the same experimenter. The æcidia obtained were not only excessively abundant but spore-formation continued vigorously for about three weeks.

ÆCIDIUM OSMORRHIZÆ PECK FROM WASHINGTONIA CLAYTONI (OSMORRHIZA BREVISTYLIS.)

Exp. 9. April 26. Aecidiospores sown on Chaerophyllum procumbens.
— Teleutospores May 17.
Exp. 10. April 26. Aecidiospores sown on Chaerophyllum procumbens.
— No infection.
Exp. 13. April 27. Aecidiospores sown on Chaerophyllum procumbens, out doors.
— No infection.
Exp. 28. May 5. Aecidiospores sown on Washingtonia claytoni.
— No infection.

Exp. 29. May 5. Aecidiospores sown on Washingtonia claytoni.
— A few sori May 30. (Was this accidental?)
Exp. 30. May 5. Aecidiospores sown on Washingtonia claytoni.
— No infection.
Exp. 31. May 5. Aecidiospores sown on Washingtonia claytoni.
— No infection.

Though apparent success attended some of the above experiments, none are considered satisfactory. While there is perhaps no doubt but that the Rust is the same on Chærophyllum and Osmorrhiza, American Uredinists have not to my knowledge made cultures for demonstration.

The eight forms of spores so far named in the above list of experiments have yielded positive results (though doubtful in the case last cited above). All those that follow gave negative results; none of these need comment however except the first below, namely, that of Puccinia peckii (DeToni) Kellerm.

PUCCINIA PECKII (DeTONI) KELLERM. FROM CAREX TRICHOCARPA.

Exp. 34. May 8. Teleutospores sown on Lycopus sinuatus.
— No infection.
Exp. 35. May 8. Teleutospores sown on Onagra biennis.
— No infection.
Exp. 36. May 8. Teleutospores sown on Sambucus canadensis.
— No infection.
Exp. 37. May 8. Teleutospores sown on Senecio obovatus.
— No infection.

It is not explicable that failure should have resulted in case of Experiment 35. But the teleutospores used were not from the same locality as that for the material used in the third set of experiments (No. 26 being successful); the locality was a mile distant and the spores seemed to differ a little in size from the former material. Further study will be devoted to this case. The host was not vigorous which may possibly explain failure when spores of Aecidium sambuci were used.

UROMYCES ANDROPOGONIS TRACY FROM ANDROPOGON VIRGINICUS.

Exp. 61. May 31. Teleutospores sown on Cimicifuga racemosa.
— No infection.
Exp. 62. June 21. Teleutospores sown on Cimicifuga racemosa.
— No infection (but the host plant not vigorous).

PUCCINI EMACULATA SCHW. ON PANICUM CAPILLARE.

Exp. 53. May 20. Teleutospores sown on Lycopus sinuatus.
— No infection.
Exp. 54. May 20. Teleutospores sown on Impatiens biflora.
— No infection.
Exp. 55. May 20. Teleutospores sown on Boehmeria cylindrica.
— No infection.
Exp. 56. May 20. Teleutospores sown on Ptelea trifoliata.
— No infection.

Exp. 57. May 20. Teleutospores sown on Sambucus canadensis.
— No infection.
Exp. 60. May 25. Teleutospores sown on Impatiens biflora.
— No infection.

PERIDERMIUM PINI WALLR. FROM PINUS RIGIDA.

Exp. 48. May 18. Aecidiospores sown on Lycopus sinuatus.
— No infection.
Exp. 49. May 18. Aecidiospores sown on Senecio obovatus.
— No infection.
Exp. 50. May 18. Aecidiospores sown on Senecio obovatus.
— No infection.
Exp. 51. May 18. Aecidiospores sown on Pentstemon pubescens.
— No infection.
Exp. 52. May 18. Aecidiospores sown on Aster sagittifolius.
— No infection.
Exp. 59. May 22. Aecidiospores sown on Solidago flexicaulus, out doors.
— No infection.

UREDO CHÆROPHYLLI FROM CHÆROPHYLLUM PROCUMBENS.

Exp. 12. April 27. Uredospores sown on Washingtonia Claytoni, (Osmorrhiza brevistylis), out doors.
— No infection.

ÆCIDIUM URTICÆ SCHUM. FROM CAREX RIPARIA.

(obtained by inoculation.)

Exp. 58. May 21. Aecidiospores sown on Carex riparia.
— No infection.

ÆCIDIUM NESÆÆ GER. FROM DECODON VERTICILLATUS.

Exp. 64. June 22. Aecidiospores sown on Carex frankii.
— No infection.
Exp. 65 June 22. Aecidiospores sown on Carex asa-grayi.
— No infection.

AECIDIUM ACTÆÆ OPIZ. FROM ACTÆA ALBA.

Exp. 62. June 21. Aecidiospores sown on Agropyron repens, in greenhouse.
— No infection.
Exp. 63. June 21. Aecidiospores sown on Agropyron repens, out doors.
— No inoculation.

ÆCIDIUM SAMBUCI SCHW. FROM SAMBUCUS CANADENSIS.

Exp. 66. June 24. Aecidiospores sown on Carex lurida.
— No infection.
Exp. 67. June 24. Aecidiospores sown on Carex lurida.
— No infection.

SUMMARY OF SUCCESSFUL INOCULATIONS WITH TELEUTOSPORES.

1. Puccinia atkinsoniana Diet. from Carex lurida Wahl.; sowings on Sambucus canadensis produced spermogonia and æcidia.

2. Puccinia bolleyana Sacc. from Carex trichocarpa Muhl. (Indiana); sowings on Sambucus canadensis sparingly produced spermogonia and æcidia.

(See foot-note (5) on previous page.)

3. Puccinia peckii (DeToni) Kellerm., P. caricis Auct., from Carex trichocarpa Muhl.; sowings on Onagra biennis (L.) Scop. (Oenothera biennis L.) produced abundant spermogonia and æcidia.

4. Puccinia caricis (Schum.) Reb. from Carex scoparia Schk.; sowings on Urtica gracilis produced abundant æcidia.

5. Puccinia caricis (Schum.) Reb. from Carex stricta Lam.; sowings on Urtica gracilis produced abundant æcidia.

6. Puccinia andropogonis Schw. from Andropogon scoparius Mx. (Indiana); sowings on Pentstemon produced spermogonia. (Host killed by Damping-off fungus).

7. Puccinia windsoriæ Schw. from Tricuspis (Sieglingia) seslerioides (Mx.) Torr. (Triodia cuprea Jacq.); sowings on Ptelea trifoliata L. produced abundant spermogonia and æcidia.

NOTES ON SCLEROSPERA GRAMINICOLA.

FRANK LINCOLN STEVENS.

This peculiar fungus began its history in America under the name of *Peronospora graminicola*, being apparently first collected by Pammel at LaCrosse, Wis., a communication to Farlow of Trelease, who noted it in the Botanical Gazette, 9:39, in 1884. Next we find it mentioned by Halsted both in the Bulletin of the Botanical Dept. of Iowa Agricultural College, April 8, p. 53 and in the Botanical Gazette 11:272, with the statement of its great abundance. Again by the same writer in the bulletin of Ia. Ag. Coll. '88, p. 99 and in the Bot. Gaz. 13:56, with the remark that it is about one tenth as abundant as two years previous. Since then it has been recorded in several western states. It was not, however, until the summer of 1901 that I was aware of its abundance in the east. Collecting trips in central New York then showed the fungus not only abundant but quite destructive to the Pigeon grass, Ixophorus viridis (L) Nash. It was so conspicuous and so abundant that it might be seen at almost any time from the carriage and was of particular destructive form. It could be followed for miles on the bicycle track between Baldwinsville and Syracuse where the over arching grasses had evidently afforded facilities for the spread of the fungus by means of the scorcher's boots and pedals.

Sclerospora was collected from the following localities in New York; Amboy, Van Buren, Syracuse, Ionia, Plainsville, Baldwinsville, Warners, Geddes, Long Branch and Cross Lake.

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